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PROTOCOL TITLE: Impaired sensorimotor integration for prosodic speech production in Ataxic Dysarthria

PRINCIPAL INVESTIGATOR:

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VERSION NUMBER:

1

VERSION DATE:

11/01/2018

STUDY SUMMARY:

Investigational Agent(s) (Drugs or Devices)	
IND / IDE / HDE #	
Indicate Special Population(s)	<input type="checkbox"/> Children <input type="checkbox"/> Children who are wards of the state <input type="checkbox"/> Adults Unable to Consent <input type="checkbox"/> Cognitively Impaired Adults <input type="checkbox"/> Neonates of Uncertain Viability <input type="checkbox"/> Pregnant Women <input type="checkbox"/> Prisoners (or other detained/paroled individuals) <input type="checkbox"/> Students/Employees
Sample Size	40
Funding Source	
Indicate the type of consent to be obtained	<input checked="" type="checkbox"/> Written <input type="checkbox"/> Verbal/Waiver of Documentation of Informed Consent <input type="checkbox"/> Waiver of HIPAA Authorization <input type="checkbox"/> Waiver/Alteration of Consent Process
Site	<input checked="" type="checkbox"/> Lead Site (For A Multiple Site Research Study) <input type="checkbox"/> Data Coordinating Center (DCC)
Research Related Radiation Exposure	<input type="checkbox"/> Yes <input checked="" type="checkbox"/> No
DSMB / DMC / IDMC	<input type="checkbox"/> Yes <input checked="" type="checkbox"/> No

OBJECTIVES:

Although the role of the cerebellum for the smooth and coordinated execution of movement is generally established, little is known about how the cerebellum specifically facilitates speech movement for natural and accurate prosodic production (Duffy, 2013). Individuals with ataxic dysarthria due to cerebellar damage exhibit atypical prosodic patterns, including a monotone

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vocal quality, a variable rate of speech, and atypical phrasal stress patterns (Darley, Aronson, & Brown, 1969; Spencer & Rogers, 2005). The overall objectives of this research study are to measure control of voice f_0 , intensity, and timing in response to pitch auditory feedback perturbations (PAFPs) in individuals with ataxic dysarthria in order to characterize a potential feedback integration impairment. The rationale for this study is that atypical prosody disrupts speech naturalness and intelligibility, which current speech therapy approaches do not effectively restore due to a poor understanding of the underlying impairment. The long-term goal is to characterize the deficits in sensorimotor control in ataxic dysarthria to better understand the underlying mechanism for prosodic impairment. With this information, it is predicted that long-term therapeutic procedures can be developed that will improve therapy outcomes for individuals with ataxic dysarthria.

The central hypothesis is that the atypical prosody in ataxic dysarthria results from a disruption in the cerebellar integration of sensory feedback with prior motor plans for both immediate corrective control of intonation as well as predictive corrective control of downstream phrasal stress targets in speech. This hypothesis will be tested by perturbing voice pitch auditory feedback of speakers with and without ataxic dysarthria in sustained, steady-state vocalization and in phrase production. The findings from this experiment will help characterize vocal response differences in immediate and predictive vocal control. Inherent to this hypothesis is the prediction that patients with cerebellar ataxia will produce abnormal responses to perturbations in voice auditory feedback compared to healthy, age-matched control subjects. The differences in responses between speakers with and without ataxic dysarthria will provide indicators of the accuracy of the cerebellum in incorporating sensory feedback with online speech production. More specifically, the following aims will be tested: 1) characterize steady vocal control in ataxic dysarthria by measuring reflexive vocal f_0 responses to PAFPs in sustained, steady-state vocalization, and 2) characterize predictive vocal control of anticipatory f_0 changes by measuring the adjustment of downstream phrasal stress targets after PAFPs earlier in the phrase.

BACKGROUND:

Sensorimotor control is essential for intelligible speech through the use of sensory feedback to inform corrective adjustments in spoken output (i.e., phoneme production, phoneme sequencing, etc.) (Guenther, 2016). The cerebellum is an important neural structure for the integration of sensory feedback with motor plans for speech. When templates for speech phonemes stored in the premotor cortex are transmitted for production, the cerebellum integrates the motor plans with sensory feedback of the current phonetic and physical environment of the speech production system (Ackermann, Mathiak, & Riecker, 2007; Ackermann, 2008). The cerebellum utilizes sensory feedback to inform the timing, sequencing, and scaling of the muscular movements in the articulatory, laryngeal, and respiratory systems for the motor plans (Diener & Dichgans, 1992). The cerebellum, therefore, is mechanistically involved in the initial sequencing of the speech motor plan as well as the ongoing monitoring of production to quickly adjust production when the output does not match the intended plan (Ackermann, Mathiak, & Riecker, 2007; Duffy, 2013; Spencer & Rogers, 2005).

The cerebellum has typically been viewed as a structure to facilitate the accurate articulation and production of speech phonemes; however, it is also a likely structure for the maintenance of prosodic production and the achievement of intonational targets. Intonation consists of a series of phonological tones, according to the Autosegmental-Metrical Theory (AM Theory; Ladd, 2008; Pierrehumbert, 1980). The prominent word(s) and phrase boundaries in intonational phrases are marked by tones that define the intonation contour and facilitate the expression of linguistic and emotional meaning in prosody. For example, a rise in pitch at a phrasal boundary can indicate a yes or no question; additionally, the tones used to mark prominent words (i.e. pitch accent) can

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indicate an answer to a question, corrective or contrastive information, or a new conversational topic. These tones have phonological organization and are predictable in speech (Ladd, 2008). Due to the phonological nature of these intonational tones, it is likely that they are stored and prepared for production in a similar manner to other phonological parameters, such as phonemes in speech. If intonational patterns are stored as motor templates similar to phonemes of speech, then the cerebellum may be heavily involved in the initialization and monitoring of intonational sequences in phrases.

Damage to the cerebellum may impair the process of preparing and monitoring *intonational sequencing*, resulting in atypical prosody and reduced speech naturalness as observed in ataxic dysarthria. Intonational sequencing is the sequencing of phonological tones such as pitch accents and boundary tones. While there is general knowledge of the role of the cerebellum in speech production, little is understood about the specific role in prosodic production (Duffy, 2013). Individuals with ataxic dysarthria due to cerebellar damage demonstrate difficulty with producing complex sequences of speech, reflecting a cerebellar impairment for maintaining articulatory control of speech sound sequences (Spencer & Rogers, 2005). We theorize that the same cerebellar impairment underlies disruption in prosodic production of intonational sequences. More specifically, cerebellar impairment may disrupt steady vocal control for intonation as well as predictive vocal control in preparation for anticipated intonational targets (i.e., pitch accents or phrase boundaries).

Scientific Premise for Aim #1: We can study the cerebellar role of *steady vocal control* by measuring the reflexive vocal response to pitch auditory feedback perturbations (PAFPs) in sustained, steady-state vocalization in individuals with ataxic dysarthria due to cerebellar damage. Similar studies have been performed in which researchers have applied movement displacements to other motor domains such as steady posture control (Horak & Diener, 1994). Individuals with cerebellar damage consistently produce hypermetric responses in their posture, meaning that they overshoot the appropriate magnitude of a corrective response, resulting in disequilibrium. Monkeys with cerebellar damage similarly overshoot the force needed for jaw force control and the control of vocalization (Larson & Sutton, 1978; Larson, Sutton, & Lindeman, 1978).

We are interested in investigating whether the same overshoot and hypermetric response will be observed in vocal pitch responses to PAFPs in individuals with ataxic dysarthria as have been reported in other motor systems. The manipulation of auditory feedback during speech production to measure sensorimotor control of speech is an established methodology (Bauer & Larson, 2003; Burnett et al., 1998; Chen et al., 2007; Larson et al., 2000; Liu et al., 2009). In this first aim, we will compare steady vocal control in speakers with and without ataxic dysarthria by comparing the magnitude and timing of their vocal f_0 responses to PAFPs during sustained vocalization. Healthy speakers are observed to make reflexive vocal responses quickly following PAFPs, interpreted as a corrective mechanism to maintain vocal control (Burnett et al., 1998; Chen et al., 2007). We predict that speakers with ataxic dysarthria will produce *larger f_0 (hypermetric responses) and delayed responses* when compared with control speakers. This result would reflect the cerebellar impairment for integrating the feedback mismatch with the prior motor plan to quickly and accurately scale the corrective response.

Scientific Premise for Aim #2: In the second aim, we will measure the *predictive vocal control* for anticipatory intonation targets (pitch accents) in phrase production. In a preliminary study, healthy speakers adjusted the mean f_0 , f_0 range, intensity, and duration of a phrase-final pitch accent in response to a PAFP at the start of a speech phrase (Hilger et al., submitted). These adjustments may reflect the preparatory role of the cerebellum to revise downstream motor plans of intonation targets according to the new phonetic and physical environment of the phrase. Predictive vocal

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control may be important for the salient production of the pitch accents in relation to the production of other words in the phrase. Without these adjustments, the salience of the production of the pitch accents may compete with surrounding words and syllables that are not intended to be accented.

The cerebellum is important for predictive control and timing of muscular actions (Manto, 2010; Manto et al., 2012). Individuals with cerebellar damage exhibit a predictive motor timing deficit for moving to hit a target (Bareš et al., 2010). A disruption in predictive vocal control may explain the atypical prosodic patterns observed in ataxic dysarthria. In both phrase production tasks and in spontaneous speech, speakers with ataxic dysarthria are perceived to produce a greater number of pitch accents per phrase than healthy speakers (Lowit & Kuschmann, 2012; Lowit, Kuschmann, & Kavanagh, 2014). The increased number of perceived pitch accents significantly increases listener error for identifying the stressed word in the phrase (Lowit, Kuschmann, & Kavanagh, 2014). It is possible that listeners may perceive words that are not intended to be pitch accented as accented, because the speaker failed to use predictive vocal control to appropriately adjust and enhance the production of downstream pitch accent(s) in the phrase. We will examine the adjustment of downstream pitch accents by applying a PAFP early in the phrase and measuring the resulting acoustic modifications. *We predict* that individuals with ataxic dysarthria will make *fewer adjustments to the f_0 and duration of the downstream pitch accent* compared to control speakers because of an inability to use predictive vocal control of anticipatory intonation targets.

STUDY ENDPOINTS:

The primary endpoint will be enrollment of 30 participants in each of the two groups who meet the criteria for the final study sample. The secondary endpoint will be analysis of the data and manuscript publication for the study aims outlined above.

STUDY INTERVENTION(S) / INVESTIGATIONAL AGENT(S):

N/A

PROCEDURES INVOLVED:**Screening and Written Consent**

To ensure that participants meet the inclusion criteria provided above, individuals who respond to recruitment flyers or emails, or who are referred by a consulting physician will undergo a telephone, email, or in-person interview screening based on the script examples provided in Appendices A1-A2. Only individuals who meet the inclusion criteria and do not meet exclusion criteria will be scheduled for further screening.

Written consent will be completed at the beginning of the first study session. The process of obtaining consent will take approximately 10 minutes. Individuals who consent to participate will be asked questions about their medical history to confirm that they meet the inclusion criteria and to obtain detailed information about related health issues. Questions regarding individuals' medical history will be answered by individual's self-report and with medical record review when available. Interview script examples are provided in Appendices B1-B2. Individuals who meet the inclusion criteria based on the interview will participate in cognitive screening using the Montreal Cognitive Assessment (Nasreddine, 2016; see Appendix C for test example). This is a cognitive evaluation tool that has been used in numerous studies including those individuals with dysarthria and was shown to be sensitive to cognitive deficits (e.g., Martel et al., 2014). Participants may complete paper or electronic versions of the test. The assessment will be completed in

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less than 10 minutes. If participants score below 19/30 points based on the test normative data, this is an indication that they have more than a mild cognitive impairment and will therefore be excluded from the study. If participants score 19 points or above, they will proceed with the experimental testing described above.

Hearing Threshold Test

All participants will complete a hearing threshold test to document their hearing sensitivity. This test will involve listening to pure tones (octave intervals between 125 and 8000 Hz) presented bilaterally beginning at 30 dB HL (approximately the loudness of a whisper), based on the American Speech-Language-Hearing Association (2005) guidelines. Participants will be asked to indicate when they hear a tone by pressing a button. If participants do not respond to the tone, the intensity will be incrementally changed until the hearing threshold is determined. The hearing test will take approximately 10 minutes. Please see the hearing threshold test form in Appendix D.

Audio Recordings

All participants will wear a headset microphone for audio recordings of speech. Their speech will be recorded during trials with and without auditory feedback perturbations during sustained vocalization and phrase production. Auditory feedback will be presented via headphones or insert earphones with disposable foam tips. Visual cues will be presented via computer monitor or other digital display (e.g., sound level meter). The microphone and headphones will interface with a soundcard, amplifier, and computer. Each auditory feedback experiment will last no longer than 20 minutes and may be repeated for a total of up to 2 hours per session. These procedures include trials with less than 8 seconds of sustained phonation and brief rest breaks between each trial.

Participants with and without ataxic dysarthria will also have their speech recorded while producing various speech tasks that do not include auditory feedback manipulation. These tasks include picture naming, sentence imitation, passage reading, narrative storytelling, and spontaneous speech production. See Appendix E for examples of speech tasks. Speaking tasks will be completed in less than 1 hour per session and will be interspersed with the aforementioned auditory feedback paradigms to minimize boredom.

The potential risks associated with these recordings are discomfort with deep insertion of the ear tips, vocal fatigue, and boredom with repetitive tasks. Ear tips will be placed quickly and with care to minimize discomfort. Participants will be offered rest breaks and will be allowed to take rest breaks at their request to minimize fatigue and boredom. In addition, participants will be provided with water to drink in between tasks to minimize vocal fatigue and dryness.

Perceptual Ratings

Participants with and without ataxic dysarthria will complete perceptual rating scales about their voice, speech, cognitive and swallowing function, quality of life, and about task difficulty and preferences. Participants will be asked to read questions and use rating scales to record their responses via computer, iPad, written, or verbal responses. Some scales may be administered using Redcap (e.g., PROMIS scales). Participants may be

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asked to produce face, arm, and leg movements and to speak and to write in order for the researchers to complete movement rating scales. Please see Appendices F1-F5 for rating scale examples. Perceptual ratings will be completed in less than 1 hour per session and will be interspersed with the auditory feedback and speech production experiments. There are no known or anticipated risks associated with these procedures.

Additionally, the audio recordings may be perceptually evaluated by listeners who are not a part of this study. These listeners will be recruited similar to the control participants in this study. When the listeners report to a study location for this part of the study, the researcher will explain the general nature of the experiment to the study. The listener will then listen to and rate de-identified audio recordings based on measures of intelligibility and naturalness using either a paper or computerized form. Listener's ratings will be de-identified.

Cognitive Assessments

In addition to the cognitive screening described above, participants may also complete selected National Institutes of Health (NIH) Toolbox batteries for a comprehension and quick assessment of cognitive, motor, and sensory function. All batteries will be completed on a computer or an iPad. The Cognition Batteries for assessment of attention, memory, executive function, processing speed, and/or language may be administered and completed in less than 45 minutes. Participants may also complete the Motor Battery for assessment of strength, coordination, and/or endurance. Motor tests will be completed in less than 30 minutes. Finally, the Sensation Battery for assessment of audition, vision, and quality of life may be administered and will be completed in less than 30 minutes. The scores on these tests will be used to determine if there is a relationship between cognitive, motor, or sensory function and responses to auditory feedback perturbation. There are no known or anticipated risks associated with these procedures.

If participants agree to video recording on the consent form, all of the procedures above may be video recorded to aid with data collection and analysis.

DATA AND SPECIMEN BANKING

Audio and video recordings and scanned data collection forms will be stored on a password protected laboratory server. Each participant will be referenced using a code that is void of identifiable information, and all data will be labeled with this code. Any identifiable information that is provided in medical records will be obscured before the records are scanned. Paper forms will be stored in a locked cabinet inside the Speech Physiology Lab.

Before publication, only the PI, faculty mentors, and laboratory members who have IRB approval will have access to the data. After publication, anonymous data will be made available at the Open Science Framework (<http://osf.io/>) so that other investigators can verify or follow-up on the reported analyses.

SHARING RESULTS WITH PARTICIPANTS

At the conclusion of each participant's final study session, the participant will be provided a brief explanation of the study if they express that they would like to hear about it.

STUDY TIMELINES

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The duration of study participation for individuals with ataxic dysarthria and healthy controls would be up to two sessions lasting no longer than four hours. If participants are unable to complete all of the study tasks in two sessions, they may be invited to return for an additional session. It is anticipated that study enrollment will be completed within 24 months and that the primary analyses will be completed within three years.

INCLUSION AND EXCLUSION CRITERIA

Participants will be screened for eligibility using a screening questionnaire administered by phone, email, or in an in-person interview (see Appendices A1-A2 for examples of these questions). The inclusion and exclusion criteria for the final study sample are presented in the table below:

Group	Inclusion Criteria	Exclusion Criteria
Individuals with ataxic dysarthria	-Diagnosed with ataxic dysarthria by a speech-language pathologist -Native fluency in American Standard English -Ability to read English -Ability to follow instructions and pay attention to tasks	-History of surgery on the oral cavity, larynx, pharynx, or respiratory system that currently affects speech or voice -Current respiratory disorder unrelated to ataxic dysarthria that affects speech or voice -Score below 19 points on the Montreal Cognitive Assessment
Healthy Controls	-Ability to read English -Ability to follow instructions and pay attention to tasks	-Current neurological disorder -Current speech, language, cognitive, or voice disorder -Current respiratory disorder that affects speech or voice - History of surgery on the oral cavity, larynx, pharynx, or respiratory system that currently affects speech or voice - Score below 19 points on the Montreal Cognitive Assessment
Healthy Listeners	-Ability to read English -Ability to follow instructions and pay attention to tasks	-Current neurological disorder -Current speech, language, cognitive, or voice disorder -Current respiratory disorder that affects speech or voice - History of surgery on the oral cavity, larynx, pharynx, or respiratory system that currently affects speech or voice - Score below 19 points on the Montreal Cognitive

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		Assessment
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We will also exclude each of the following special populations:

- Adults who are unable to consent
- Individuals who are not yet adults (infants, children, teenagers)
- Pregnant women
- Prisoners

VULNERABLE POPULATIONS

N/A

PARTICIPANT POPULATION(S)

Accrual Number:	Category/Group: (Adults/Children Special/Vulnerable Populations)	Consented: Maximum Number to be Consented or Reviewed/Collected/Screened	Enrolled: Number to Complete the Study or Needed to Address the Research Question
Local	Participants with ataxic dysarthria	40	30
	Healthy Controls	40	30
	Healthy Listeners	100	30
Study-wide	N/A	N/A	N/A
	N/A	N/A	N/A
Total:	Total participants	180	90

RECRUITMENT METHODS

Participants will be recruited from flyers and study information in the Northwestern Medicine Ataxia Clinic, Neurology, and Speech Therapy Departments; the Northwestern University Audiology, Speech, Language, and Learning Clinic; and the Shirley Ryan AbilityLab by their clinical providers or by research team members when they are seen for assessment or treatment. Dr. Puneet Opal, a neurologist at the Northwestern Medicine Ataxia Clinic, frequently sees patients with ataxic dysarthria due to degenerative conditions such as Friedrich’s Ataxia and Spinocerebellar Ataxia. Clinical providers will be informed of inclusion and exclusion criteria to aid in identification of potential participants. Clinical providers and research team members may also share recruitment flyers with past patients via mail or email if patients previously volunteered to participate in research. In addition, clinical providers may share patients’ names and contact information with the study members if they previously agreed to be contacted about future research studies. Other potential participants will be recruited with study flyers posted or distributed at university and clinical settings including but not limited to Communication Disorders, Physical Medicine and Rehabilitation, and Physical Therapy departments at Northwestern University, Northwestern Medicine, and the Shirley Ryan AbilityLab. Members of professional groups (E.g., American Speech-Language-Hearing Association, Voice Foundation, National Ataxia Foundation) will be informed of the study via member email lists. Members of the National Ataxia Foundation will be informed of the study via the foundation research recruitment webpage (<https://ataxia.org/researcher-resources/#spnRecruitResearchPatients>) or via member email lists. In addition, flyers will be distributed to local NAF support groups. Flyers will also be posted or distributed in other Northwestern University departments in Evanston and Chicago and at local

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businesses (e.g., cafes, restaurants), organizations (e.g., senior centers, churches), hospitals, medical clinics, support groups, and speech and hearing clinics with site permission. Study information will also be shared on Facebook and with the Communication Research Registry maintained by the Department of Communication Sciences and Disorders. Please see Appendices A1-A2 and G1-G2 with recruitment flyers and letters and email scripts.

COMPENSATION FOR PARTICIPATION IN RESEARCH ACTIVITIES

Participants will be reimbursed in cash for valet parking at the Shirley Ryan AbilityLab or will be provided with complementary parking at Northwestern University for their study sessions. They will be compensated \$10/hour in cash at the conclusion of each study session.

WITHDRAWAL OF PARTICIPANTS

If it is determined that participants do not meet the inclusion criteria, they will be not be included in the study and will not complete further study procedures as soon as this is determined. The rationale for their withdrawal will be explained to them and the experimenters will attempt to answer any questions that the participants have about their withdrawal. Data collected from these participants will be destroyed after their withdrawal. Participants may be withdrawn from a part of the study but continue with other data collection if a procedure is expected to cause more than minimal risk to the participant. For example, if the participant is unable to complete the Motor Battery of the NIH Toolbox, they will not participate in completing this test battery but may be invited to complete other study tasks like speech recordings.

RISKS TO PARTICIPANTS

Audio Recordings

The potential risks associated with these recordings are discomfort with insertion of the ear tips, vocal fatigue, and boredom with repetitive tasks. Ear tips will be placed quickly and with care to minimize discomfort. The ear tips will not reach the eardrum. Participants will be offered rest breaks and will be allowed to take rest breaks at their request to minimize fatigue and boredom. In addition, participants will be provided with water in between tasks to minimize vocal fatigue and dryness.

Perceptual Ratings

There are no known or anticipated risks associated with these procedures.

Cognitive Assessments

There are no known or anticipated risks associated with these procedures.

POTENTIAL BENEFITS TO PARTICIPANTS

There are no known benefits to participants.

DATA MANAGEMENT AND CONFIDENTIALITY

Data will be collected in a private clinical space or laboratory to maintain patient confidentiality. Data will be labeled with a code that is void of identifiable information and will be stored on a password protected laboratory server. Only the PI, faculty mentors, and laboratory members who have IRB approval will have the access to the data. Data analysis will include acoustical analysis of audio recordings, quantitative analysis of screening and cognitive assessments, and listener perceptual ratings.

PROVISIONS TO MONITOR THE DATA TO ENSURE THE SAFETY OF PARTICIPANTS

N/A

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PROVISIONS TO PROTECT THE PRIVACY INTERESTS OF PARTICIPANTS

Participants will report directly to the laboratory or clinical room where the research will take place or to the nearby waiting area to prevent individuals who are not involved in this research from knowing their participation. Only the PI and study team members who are directly involved in the study will be present in the laboratory during the consent process and data collection. All personal information and recordings will be secured on the laboratory data server and will remain on the server. Each participant will be referenced using a code that is void of any identifiable information. Participants will be informed of these privacy protections. To promote participants feeling at ease, it will be explained that they are not obligated to respond to questions or participate in the research tasks if they do not want to, and that they can withdraw from the study at any time without negative consequences. In addition, they will be provided with descriptions of the procedures and tasks prior to initiating them, and they will be offered opportunities to ask questions before, during, and after procedures.

Study team members will have access to medical records only if they are approved by the IRB and have completed HIPAA training. Medical records will be maintained on clinical servers and systems unless they are released directly by study team members. In this case, identifiable information will be obscured before records are scanned and saved on the laboratory data server. Paper records will be stored in a locked cabinet in the Speech Physiology Lab.

COMPENSATION FOR RESEARCH-RELATED INJURY

N/A

ECONOMIC BURDEN TO PARTICIPANTS

Participants will be responsible for transportation costs to and from the study sites with the exception of the parking fees. Participants will be re-imbursed for the cost of parking but not the cost of transportation (i.e., vehicle gas, public transportation fee). Every effort will be made to provide participants with the opportunity to participate at the site that is most convenient and closest to their home or work.

CONSENT PROCESS

Doctoral or undergraduate students will be involved in consenting participants to the research if they are approved by the IRB to obtain consent for this protocol. The Principal Investigator will ensure that the correct procedures for obtaining consent are carried out. The consent process will take place in a quiet, private laboratory or clinic room. The consent discussion is expected to take approximately 10 minutes. Participants will be encouraged to read the entire consent form and to ask any questions that they might have. The study team member(s) will attempt to answer all of the participants' questions. Participants will be informed verbally and in writing that their participation is completely voluntary and that they may withdraw from the study at any time without negative consequences. There will be no waiting period between informing the participant about the study and obtaining consent unless the participant requests a waiting period. The participants will indicate their consent in writing by signing their initials on each page of the consent form and by providing their signature on the last page of the consent form. The consent form will be provided in English because only individuals who speak and understand English will be included in this study. If participants have difficulty reading the consent form, a study member will read the form aloud. Participants will be given a copy of the signed consent form for their records. Participants will be provided with descriptions of procedures and tasks prior to initiating them and ongoing consent will be confirmed periodically throughout the study. Participants will be asked to confirm their understanding and will be encouraged to ask questions. Study team members will

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avoid any verbal and non-verbal language that might coerce or exert any undue influence on the participant during the consent process or through the study.

WAIVER OR ALTERATION OF CONSENT PROCESS

N/A

PROTECTED HEALTH INFORMATION (PHI AND HIPAA)

Participants will report directly to the laboratory or clinic room where the research will take place or to a nearby waiting area to prevent individuals who are not involved in this research from knowing about their participation. Only the PI and study team members who are directly involved in the study will be present in the laboratory or clinic room during the consent process and data collection. All personal information and recordings will be secured in the laboratory data server and will remain on the server. Each participant will be referenced using a code that is void of any identifiable information. Participants will be informed of these privacy protections. To promote participants feeling at ease, it will be explained that they are not obligated to respond to questions or participate in the research tasks if they do not want to, and that they can withdraw from the study at any time without negative consequences. In addition, they will be provided with descriptions of procedures and tasks prior to initiating them and they will be offered opportunities to ask questions before, during, and after procedures.

Study team members will have access to medical records only if they are approved by the IRB and have completed HIPAA training. Medical records will be maintained on clinical servers and systems, unless they are released directly by study team members. In this case, identifiable information will be obscured before records are scanned and saved on the laboratory data server. Paper records will be stored in a locked cabinet in the Speech Physiology Lab.

NON-ENGLISH SPEAKING PARTICIPANTS

N/A

QUALIFICATIONS TO CONDUCT RESEARCH AND RESOURCES AVAILABLE

Personnel:

The Principal Investigator for this study, Charles Larson, Ph.D., is a Professor of Communication Sciences and Disorders. He has mentored seven postdoctoral trainees and 17 doctoral students, has authored over 95 peer-reviewed research articles, and has been funded by 11 National Institutes of Health grants. His extensive research and mentoring experience will be invaluable for providing the guidance, training, and support needed for this study. He is frequently and regularly available to provide study oversight.

Additionally, two researchers have agreed to collaborate on this research study. Puneet Opal, M.D., Ph.D., is a Professor of Neurology and Cell and Molecular Biology as well as a Neurologist in the Movement Disorders Clinic at the Northwestern Memorial Hospital. Dr. Opal has extensive experience and expertise conducting research experiments with individuals with ataxia and other movement disorders. Leora Cherney, Ph.D., CCC-SLP, is a Professor of Physical Medicine and Rehabilitation at Northwestern and is the Senior Research Scientist at the Shirley Ryan AbilityLab. Dr. Cherney has expertise and extensive experience conducting clinical research on rehabilitation of communication disorders.

Allison Hilger, MS, CCC-SLP, is a doctoral student in Charles Larson's Speech Physiology Lab. She has been a certified speech-language pathologist for three years and has been involved in

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research for six years at seven different research laboratories. She has training in all of the research procedures involved in this study including audio recordings and speech, language, cognitive, and motor assessments. Allison Hilger will be working full-time on these studies. Dr. Larson will provide training and oversight for other doctoral and undergraduate students who may assist with data collection and analysis. All study team members are familiar with the study sites or will be familiarized with the study sites before the studies are conducted. Students will receive training on the protocol and will be observed performing the protocol before they independently perform any of the study components. Duties will be clearly outlined during training.

Setting:

This research will be conducted at the Northwestern University Center for Audiology, Speech, Language, and Learning (2315 Campus Drive, Evanston, IL) or the Speech Physiology Laboratory (2240 Campus Drive, Evanston, IL), the Northwestern Medicine Ataxia Clinic (259 East Erie Street, Chicago, IL), the Opal Lab located in the Northwestern Memorial Hospital (303 E Chicago Ave, Chicago, IL), and the Shirley Ryan AbilityLab (355 East Erie, Chicago, IL). Research procedures will be performed in a quiet, private laboratory or clinic room setting. Potential participants will be recruited from the Neurology and Speech Therapy departments of Northwestern Medicine; the Center for Audiology, Speech, Language, and Learning Clinic of Northwestern University; the Shirley Ryan AbilityLab; and the National Ataxia Foundation. In addition, flyers will be posted or distributed to other Northwestern University departments and Northwestern Medicine offices in Evanston and Chicago and at local businesses (e.g., cafes, restaurants), organizations (e.g., senior centers, churches), hospitals, medical clinics, support groups, and speech and hearing clinics with site permission.

With access to potential participants at the listed recruitment sites, it is feasible that up to 30 participants with ataxic dysarthria and up to 30 healthy speakers will be recruited for this study. The Speech Physiology Laboratory, the Center for Audiology, Speech, Language, and Learning, Northwestern Medicine, and the Shirley Ryan AbilityLab house all of the necessary equipment for this study. The available equipment includes Power Lab multi-channel recording equipment, MOTU digital audio interface, Bruel & Kjaer Sound Level Meter, and a variety of microphones and headphones. In addition, laptop and desktop computers are available with software for data collection and analysis including LabChart, Praat, Igor Pro, Matlab, SPSS, R Studio, Pitch Present, Pitch Brose, and Speech Analysis Web Application.

STUDY-WIDE RECRUITMENT METHODS

N/A

References

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